Unified Billing-Realization of convergent architecture for charging and billing in 4G networks

Prakash.S [1], Kashyap dhruve [2], and C.B.Akki [3]

[1] Department of ISE, East Point College of Engineering & Technology, Bangalore, India
Email: prakash_hospet@rediffmail.com

[2] Technical Director, Planet-i Technologies, Bangalore, India
Email: kashapdhruve@hotmail.com

[3] Senior Consultant, Wipro Technologies, Bangalore
Email: channappa.akki@wipro.com

Abstract—**4G is expected to get deployed by many telecom companies in this year. Technologies employed by 4G being tested and going to hit the commercial market soon. When fully implemented, 4G is expected to offer high speed transmission and provide seamless handoffs across multiple high speed heterogeneous networks. These heterogeneous networks on converged platform provide access to varied services over an IPv6 core. Convergence & high speed would provide opportunity to end user to use compounded services from varied network providers; this will lead to big challenge for accounting, Charging and billing. This paper in continuation of our previous papers [7][21] discusses a Convergent Framework Architecture (CFA) which provides a unified bill to the user for all his compounded usage across varied network operators. The CFA introduces a trusted third party operator called the Convergent Network Operator (CNO) to achieve a transparent charging, accounting and unified billing provisions. The functionality of the CFA is demonstrated with a prototype. We were able to realize unified bill to end user for the usage of different type of service from varied network providers. This concept and business model will bring better Quality of service (QoS) not only at competitive price but also provide independence and choice to users to opt for specific services from Quality network operators. These instructions give you basic guidelines for preparing camera-ready papers for ACEEE's conference proceedings/Journal Publications.**

*Index Terms - 4*G Networks, Convergent Network Operator, Convergent framework architecture, Ipv6, Unified Billing,

I. INTRODUCTION

The 4G Network would be convergence of heterogeneous networks over IPv6 core. The technologies employed by 4G will be LTE Advanced, WiMax, Ultra Mobile Broadband etc.4G will provide high throughput transmission with theoretical 100Mbps download. The world wireless research forum predicts that around 17 Trillion devices will be connected for seven billion people by 2017[6]. Recent survey done on 4G deployment status across globe show that there are 22 LTE technology networks in 16 countries; nearly 50 launches expected before end of 2011,86 in trail and 168 planned for deployment [18]. There will be multiple services providers; equipped with varied technologies offering varied services for the benefits of the users. Currently users are all Service Provider bound. They enjoy services provided by their home

network operator. The consumers would have the freedom to select a service or services provided by one or many providers and obtain a single bill based on their usage. The generation of unified bill for used services from different service providers would be the future scenario. These heterogeneous networks with multiple operators offering varied services would pose huge accounting and billing challenges. Then it becomes necessary to have a common trustworthy platform to regulate & bring transparency in accounting and billing provisions that facilitate both user and service providers. Currently the consumers are charged based on usage and subscription from home network service provider. The inter network operator services have not been integrated except while on roaming. After complete deployment of 4G networks there will complete paradigm shift that would result in an integrated billing architectures where consumers would be charged based on their usage of services via a single bill. These kinds of architectures would result in consumer independence, better quality of services at competitive price and better support systems. In this paper we have attempted to realize unified bill for the user using varied services from varied network operators. We have proposed a trusted third party convergent framework Architecture that need to be established by local or global governing bodies like the ITU,IEFT, 3GPP,etc. The CFA would also provide freedom to the users in selecting varied operators for varied services, the transparent nature of the CFA would also thrust development of better communication technologies and add to the overall business growth. The CFA considers all the network operators (NWO) with its service providers and other operational partners as a single entity.

II. RELATED WORK

There are various architectures for charging, accounting and billing from its emergence [11]. Acceptance and realization of new architectures is a question of harmonizing the cost and benefits of deployments both to the users and the network operators. The new architectures are generally demand driven. The growing demand gives birth to new protocols, new designs and new technologies leading to betterment of the current deployments. These architectures are service provider centric and have been deployed at service provider premises. In these service oriented Architectures[17]; currently consumers of the current mobile

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technology are bound to a single network operator. There exists many SLAs (Service Level Agreements) between Access Provider, Transport Provider, Content Provider and service Provider for transperent billing.The network Operator need to adhere with these SLAs for fair and transperent billing procedures[23]. There are other architectures like compensation architecture [5], an UMTS based billing architecture [9][10], and reusable ticket based architectures [25]. These architectures are established as per the 3GPP standards [1]. Network Intra Operating Agent architecture [23] capable of managing Intra Network Operators using various service level agreements (SLA), integrated WLAN, CDMA2000 and Satellite Networks.The ANWIRE project for accouting and billing proposes the use of an external third party agent for maintenance of authentication, authorization and accounting (AAA) servers [8]. Diameter Attribute Value Paris protocol [12] was built to extend the existing AAA server deployments for billing and accounting. However this architecture lacked scalability and reliability. Charging Accounting and Billing service built over an Open Service Interface addresses the users or consumers requirement for a one stop billing provision [19][26]. Convergent Service Platform [22][16][3] with open service architectures [4][16][26] could be considered as a solution to these issues which could benefit both the network operators and the users. Governing organizations such as 3GPP and other telecommunication standardizing bodies such as IRTF, IETF, ITU, ETSI, WG5, AAA and AAARCH need to be involved to realize a convergent platform. The convergent platform would integrate over an IPv6 packet switched core[4]. The Billing model of these architectures requires the suitable information for billing. The table 1 below shows the billing information for respective billing models [3]. The CFA discussed below is designed to address many issues with respect to single user node billing, financial transaction security, distribution transparency, and grievance management from both the users and the network operators. As the CFA would provide financial assurance to the network operators and the user nodes, it has to be monitored or established by local or global governing bodies like 3GPP, ITU, IEFT, etc.

TABLE I: REQUIREMENT INFORMATION OF BILLING MODEL [3]

Billing models	Billing Information
Flat-Fee billing	Basic Price, Price Unit, Rate
Volume Billing	Data, Value of transaction, Value Unit.
Content billing	Data, Value of Transaction, Value Unit, Content type, content price
Time billing	Time(start time, End time, Time stamp),Basic price, Price Unit
Number Billing	Content Name, Content type, Content price
QoS Billing	Bandwidth, Delay, Jitter, Reliability, priority.

III. PROPOSED ARCHTECTURE—CFA

The proposed CFA on converged platform facilitate the users to select their preferred service from the preferred network operator to realize a single bill

The CFA mainly constitutes three entities:
1.	Convergent Network Operator (CNO)
2.	Network Operators (NWO)
3.	User Nodes or Terminals (UN)

The CNO is assumed to be a trusted entity that converge all the NWOs-UNs on IPv6 core platform. It maintains service level agreements (SLAs) between all the NWOs offering varied services. Each user UN is identified by International Mobile Subscriber Identity (IMSI) for the realization of a single bill per UN. The CNO will regulate with its strong SLAs for providing financial assurance to the NWOs for the usage of its services. The NWO constitutes Access Providers, Transport Providers, Content Providers and Service Providers. It maintains strong SLAs among all these units. The CFA treats NWO as single entity offering varied services through physical distribution network. The pricing of the services offered by NWO is independent of the CFA and the dynamics of competitive pricing is decided by the NWO itself. The NWO just provides the Charging Function (CF) through a cost matrix. The UN identified by unique IMIE/IMSE number is an independent entity and has front end application that will enable to choose any NWO for varied services. The user (UN) has option to choose any schemes and offer for specific service from any NWOs. The UN would get single bill for the usage of multiple services from multiple operators. This model could be considered as an open business model and it would accelerate the provision of enhanced Quality of Service (QoS). In order to provide better QoS and retain UN's, the NWO's would need to enhance their current technology and service offering propelling technological development.

Basic Operation of the CFA

The CFA incorporates the monitoring, billing and charging functionality based on the sessions created by the UN. Every session is monitored and the UN obtains a unified bill based on the session usage. Let M denote a set m independent network operators and N be a set of n network services offered. Each network operator $M_i\{i\tilde{o}1,2\ldots m\}$ provides some or all of the n services of N. Let P denote the set of p user nodes availing services from the NWO. The Operation of the CFA consists of three Phases: Session Initialization Phase, Service Execution Phase and Accounting and Billing Integration Phase. The UN p_i where $i\,\tilde{o}\,\{1, 2, 3\ldots.p\}$ Request For a Service (RFS) n_i from a NWO m_i. The RFS is considered as an event. An event may vary from making a call, sending a Short Message Service (SMS), E-Mail access etc. Once the NWO receives RFS from the UN p_i for a service n_i The UN's location is detected and obtained from the Event Detection Point (EDP). The NWO ascertains whether it could provide that specific service n_i at that Location Area Code (LAC) requested by UN p_i. This operation to determine the Location Service (LCS) to map specific service for that respective location is carried out by the Service Management Unit of the NWO. If the service could be provided, a session is created. Every event initiates a session. Every event begins with the User Node Identification (UNI) information

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transmission. The UNI is assumed to consist of the IMEI and IMSI. The UN interacts with the physical network maintained by the Interface Management Unit of the NWO. Once the NWO receives the UNI it checks its User Management Unit for any subscription purchased, special pricing offered for the service ni. The NWO provides the UNI and the information from the User Management Unit to the CNO. If the UN has purchased a subscription the information is confirmed by the CNO after verifying the UN subscription validity details from its User Management Unit of the CNO. If the UN has no subscription or has a special price offering from the NWO the CNO stores the UN's RFS into the User Management Unit of the CNO. Based on the UNI information the CFO ascertains whether the UN is a pre-paid customer or a post-paid customer. If the UN is under the pre-paid scheme, a Session Validity Time (SVT) based on the balance is calculated and provided to the NWO. If the UN is under the post – paid scheme the User Credit Rating (UCR) is provided to the NWO. This operation is performed for accounting transparency. Once the UN credentials are established the NWO provides the charging function (CF) to the CNO for accounting and billing. The CF is also updated to the Converged Charging Function (CCF) maintained by the CNO. A similar CF notification is sent to the UN for confirmation of charge acceptance. Once the acknowledgment is received with confirmation, the session is activated. The session once established with the NWO mi is monitored by the Session Management Unit. Through the session established the NWO mi provides the service ni according to the RFS. The session established for service execution may abruptly be broken by either the user or due to network errors. In such case the Session Management Unit saves the Session Details and provides it to the CNO for further handoff operations. If the session is terminated normally the session details are provided to the Accounting Section of the NWO. Handover Management is another important and critical factor considered in the designing of the CFA. The handoff management unit (HMU) is embedded into the CNO in the CFA. Once the user credentials are established, and the RFS can be serviced by the NWO mi, the NWO verifies whether the session is a new one or is a continuation to a session services by another NWO. To ascertain the session type the NWO queries the CNO for the User Session Update (USU). The CNO verifies with its Accounting Management Unit whether a Charged Data Record of the UN pi considered exist for the same service. The CDR are all time stamped and stored in the accounting management unit of the CNO. If a CDR of the UN pi for the same service ni exists within a time interval Ät it could be considered as a possible handoff. The possibility of the session to be a handoff is conveyed to the NWO. The NWO sends a message to the UN querying for Session Restoration or New Session. Once the service execution of specific session is completed; those service utilization details are provided to the accounting session. Every completed session has a corresponding CF associated with it. The CF is established by the NWO and may vary from operator to operator.

The CFA considers the NWO to provide their independent charging function using their Charging Framework. The charging of services could be considered based on one of the following parameters [3]:

1. Session Time Based Charging
2. Session Volume Based Charging
3. Session-Event Based Charging.
4. Session Content Based Charging
5. Session QoS based Charging
6. User Subscription based Charging

Based on the UN pi and the RFS ni the charging function may vary. The Session Management Unit of the NWO provides the base units utilized by pi for service ni to be considered for charging. The base units to be monitored for the service ni is provided by the Charging Framework of the NWO. The Session Management Unit of the NWO monitors the user session and in accordance with the Charging Framework. The NWO provides the base units or parameters utilized to be considered for charging of the session. For example, in a video call, it could be a time based charging session. The Session Management unit provides the time units to the Charging Framework where the Charging Collection Function (CCF) is established containing the units chargeable, and the per unit price. The charging Data Record (CDR) which is a product of the Chargeable Units and the CF per unit is generated in the Accounting Section of the NWO. The CDR is sent to the Accounting Management Unit of the CNO. The various CDR's obtained by the CNO are used to update the Converged Usage Function (CUF) matrix. The Accounting Section of the CNO computes a unified bill by aggregating all the CDR pertaining to the UN's. This is considered as the Accounting and Billing Integration Phase of the CFA operation.

The security parameters and the protocols for secure communications are established in the Security Framework Layers of the CNO and the NWO. The CFA enables a single bill generation per UN. On receiving payments towards the usage of services offered or services to be offered, the CNO distributes the received amount amongst the NWO's based on the UN's usage. All the financial transactions are realized through the Payment Gateways available with the CNO and the NWO. Network Error occurrences or infrastructure malfunctions cannot be ignored in such a huge converged 4G networks. Such errors would result in grievances from both the UN's and the NWO's. A Reporting Management Unit is maintained in the CNO to record all the disparities reported by the UN's or the NWO's. The Reporting Management unit is responsible for resolution of payment and billing discrepancies to enable transparent and rewarding business model for 4G networks. This error management unit although is very critical but surprisingly not much work has been done towards providing solutions. The CFA discussed above provides an entirely new approach to resolve the issues related to convergent charging and billing solution yet providing opportunities for overall business growth.
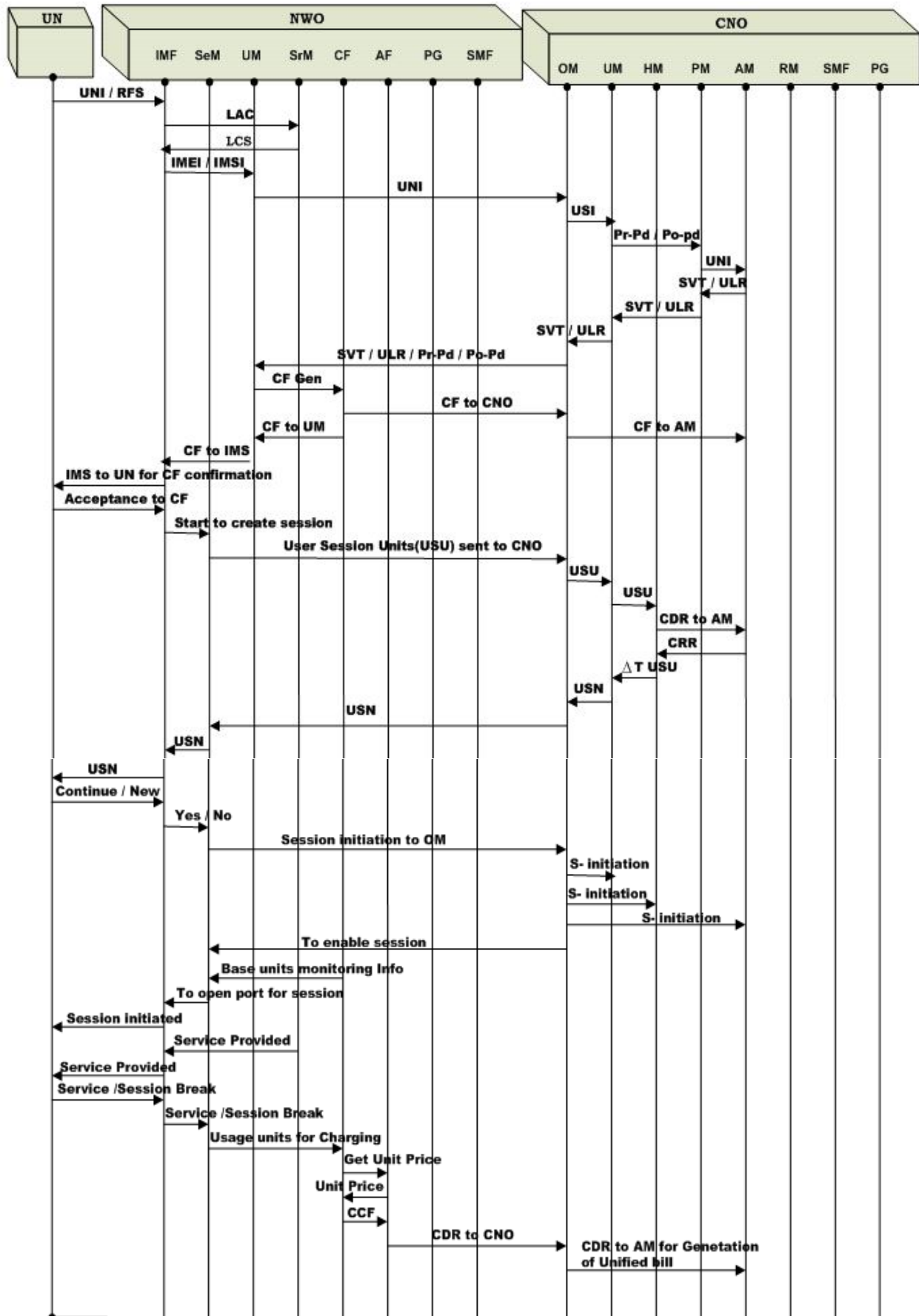
Figure 1 Basic Operation of CFA

The charging Data Record (CDR) which is a product of the Chargeable Units and the CF per unit is generated in the Accounting Section of the NWO. The CDR is sent to the Accounting Management Unit of the CNO. The various CDR's obtained by the CNO are used to update the Converged Usage Function (CUF) matrix. The Accounting Section of the CNO computes a unified bill by aggregating all the CDR pertaining to the UN's. This is considered as the Accounting and Billing Integration Phase of the CFA operation. The security parameters and the protocols for secure communications are established in the Security Framework Layers of the CNO and the NWO. The CFA enables a single bill generation per UN. On receiving payments towards the usage of services offered or services to be offered, the CNO distributes the received amount amongst the NWO's based on the UN's usage. All the financial transactions are realized through the Payment Gateways available with the CNO and the NWO. Network Error occurrences or infrastructure malfunctions cannot be ignored in such a huge converged 4G networks. Such errors would result in grievances from both the UN's and the NWO's. A Reporting Management Unit is maintained in the CNO to record all the disparities reported by the UN's or the NWO's. The Reporting Management unit is responsible for resolution of payment and billing discrepancies to enable transparent and rewarding business model for 4G networks. This error management unit although is very critical but surprisingly not much work has been done towards providing solutions. The CFA discussed above provides an entirely new approach to resolve the issues related to convergent charging and billing solution yet providing opportunities for overall business growth.

IV. MATHAMATICAL MODEL FOR CHARGING AND UNIFIED BILLING

In the CFA the CNO is responsible for generating the unified bill to UN's. This is done based on the details of the CF's and the service usage details relative to the UN's obtained from various network providers. This section would discuss the approach adopted by the CNO to derive the unified bill. Let us consider a 4G converged network having m NWOs and each NWO offering n services and these services used by p UN's. The accounting management unit of the CNO considers the Converged Charging Function (CCF) and the Converged Usage Function (CUF) for bill generation represented as

$$CCF_{(m \times n)} = \begin{bmatrix} c_{11} & \cdots & c_{1n} \\ \vdots & \ddots & \vdots \\ c_{m1} & \cdots & c_{mn} \end{bmatrix}$$

$$CUF_{(m \times n \times p)} = \begin{bmatrix} u_{111} & \cdots & u_{1n1} \\ \vdots & \ddots & \vdots \\ u_{m11} & \cdots & u_{mn1} \end{bmatrix}$$

Consider the ith NWO maintains CCF[i][1:n] and CUF[i][1:n][1:p] matrices at its location. Every RFS initiates a session over which the NWO provides the requested service and a CDR is generated.

For every CDR generated, the NWO has to update the part of CUF matrix for the usage of requested service by the UN. Every NWO should also update the CCF matrix whenever there is any change in the services or their tariffs.

The Unified Bill for k^{th} user is computed at the CNO level as follows:

1.   CDR for individual services used by the kth user are given as

$$CDR[i][j][k] = CCF[i][j] \times CUF[i][j][k]$$

$$i \in [1, m], j \in [1, n]$$

2.   Unified Bill is given by

$$UnifedBill[k] = \sum_{i=1}^{m} \sum_{j=1}^{n} CDR[i][j][k]$$

3.   This approach will also enable the CNO to provide information on the break-up of unified bill among NWOs. The UN will get information on how much it has been charged for all the services used from a NWO. The bill information for an ith service provider for k^{th} user is given as:

$$Cost\_wrt\_SP[i][k] = \sum_{j=1}^{n} CDR[i][j][k]$$

V. PROTOTYPE EVALUATION

A unified bill was realized through the prototype implementation discussed further in the paper.

Test bed setup

We have created four (NWO1, NWO2, NWO3 & CNO) independent virtual networks on windows host platform using Vmware tools. The User node UN is configured as wireless adapter to access all the four networks. The virtual network editor is used to access multiple network cards on our host machine. We have used IPv6 addressing scheme .The functionality of CFA is built on C#.NET .The Inter communications between NWOs and communications between the NWO and the CNO are implemented using the remote client server concepts. The test bed is shown in the figure 2.
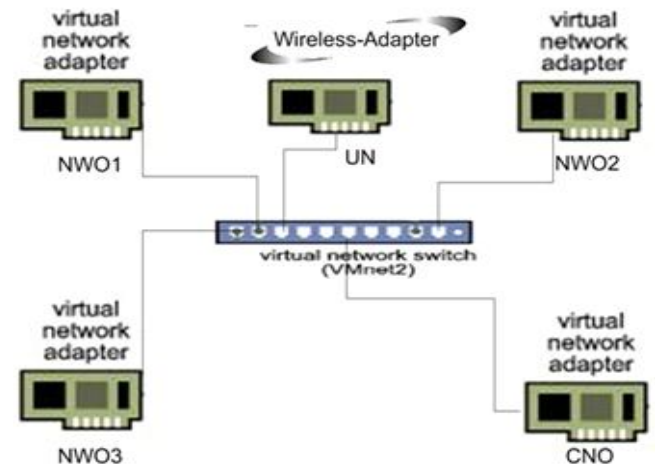
Fig 2.Testbed

Simulation operations

The test UN sends a RFS for the NWO1 using .NET Remote session. The NWO1 responds to the RFS from the test UN by sending CF for acceptance. If the CF is accepted for that type of service; the ACK is sent to NWO1.The CFs for that type of service may vary for every NWO. The NWO1 will send the intimation to CNO that the session would be started with UN. The session is activated for the requested type of service & the same is monitored concurrently with the CNO. All the data transactions within the CFA are secured through cryptographic means. Once the session is complete and gets disconnected; the usage Charging Data record (CDR) for that type of service is generated & sent to CNO for accounting and unified billing. The same operations take place for other RFSs from UN with different NWOs. The CNO calculates and generates Unified bill for UN based on the metrics discussed above.

Simulation Results

We have taken three different RFS (Type of service) of User UN asking service for NWO1, NWO2 and NWO3 respectively as sample inputs. The usage metrics of UN is calculated by CNO is as below.

$$CCF(3 \times 3) = \begin{bmatrix} (NWO1S1) & 0 & 0 \\ 0 & NWO2S2 & 0 \\ 0 & 0 & (NWO3S3) \end{bmatrix}$$

$CUF_{(1,1,1)} = [21 + 23] = [44 secs]$
$CUF_{(2,2,1)} = [46 + 60] = [106 bytes]$
$CUF_{(3,3,1)} = [18 + 12] = [30 secs]$

$$CUF(3 \times 3 \times 1) = \begin{bmatrix} 44 \ secs & 0 & 0 \\ 0 & 106 \ bytes & 0 \\ 0 & 0 & 30 \ secs \end{bmatrix}$$

$UB[1] = [44 \times NWO_1 S_1] + [106 \times NWO_2 S_2] + [30 \times NWO_3 S_3]$

The figure below represents the usage pattern of the User UN with respect to varied services opted from different Network providers generated from CNO for realization of unified billing.
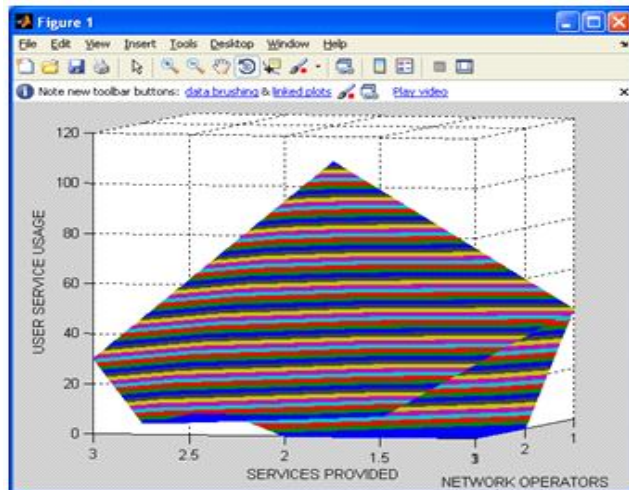

Fig 3.User usage pattern

CONCLUSIONS

The deployment of 4G will lead to Convergence of all heterogeneous networks. The 4G technology and its applications will enable the user to choose varied services from different network providers. In this paper we have proposed Convergent Framework Architecture that provides a unified billing structure for the usage of services from varied network providers. The experimental study discussed proves the possibility of such architecture for unified billing generation. The framework also describes a transparent financial model benefitting both the network operators and the users. This kind of a convergence would bring about robust technological developments owing to cumulative business growth targeted towards provision of better services to the users at highly market competitive charges. The realization of such architecture completely relies on the establishment of convergent network operators by local or global governing bodies with strong service level agreements.

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